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Hymenaea courbaril (L.) Algarrobo, locust

SO-ITF-SM-27
January 1990

Leguminosae **Legume family**
Caesalpinioideae **Cassia subfamily**

U.S. Forest Service
Pacific Southwest Library and Information Center
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Hymenaea courbaril L., commonly known as algarrobo, locust, jutaby, cuapinol, or courbaril (*19*), is a stately forest tree (fig. 1) that produces large, very hard seed pods containing a strong-smelling but edible pulp and large seeds. The rich-colored and durable wood has a variety of uses. Sawlogs are presently harvested from natural stands, although the species is amenable to plantation management.

HABITAT

Native Range

Algarrobo has a wide distribution (fig. 2). In the Caribbean, it grows throughout the Greater and Lesser Antilles. On the mainland the range extends from the west coast of central Mexico southward into Bolivia and south central Brazil (*15*, *17*), corresponding to about 23° N. through 25° S. latitudes (*15*).

Climate

Algarrobo occupies a wide range of habitats. It has been reported in the tropical dry forest, transition to premontane moist forest, and the tropical wet forest in Costa Rica (*30*) as well as the subtropical moist forest in Puerto Rico (*35*). The species also grows in the subtropical wet and tropical moist forests of the Holdridge Life Zones (*9*). The annual rainfall in the native areas varies from 2400 mm or more (*23*) to as little as 1200 mm. Algarrobo grows best in areas where rainfall averages from 1900 to 2150 mm/yr (*23*). The precipitation may be evenly distributed through the year or monsoonal. The greatest temperature differences within the range of algarrobo are found in South America, where the mean annual temperatures vary from 20 to 30 °C (*8*). Diurnal temperature fluctuations are normally greater than seasonal temperature changes.

Soils and Topography

Like most hardwoods, algarrobo grows best on deep, fertile, moist, and well-drained soils. It will grow on all textures of soil from sands to clays (*23*), but develops best on sandy soils (*19*). In Puerto Rico, algarrobo may be found on soils where the pH ranges from 4.8 to 6.8. Most genotypes grow on ridges and slopes, but they seldom grow on poorly drained bottoms (*23*). However, *H. courbaril* var. *stilbocarpa* from Brazil is reported to be flood-tolerant (*14*). Algarrobo will do better on eroded sites than most hardwoods (*21*) but will not grow on the most degraded sites (*17*). This species grows from near sea level to elevations of about 900 m (*27*).

Associated Forest Cover

Algarrobo grows in associations far too numerous to list. Four representative associations are found in Mexico, Venezuela, Puerto Rico, and Costa Rica. In the Sierra Madre Mountains of Chiapas, Mexico, algorrobo grows in a

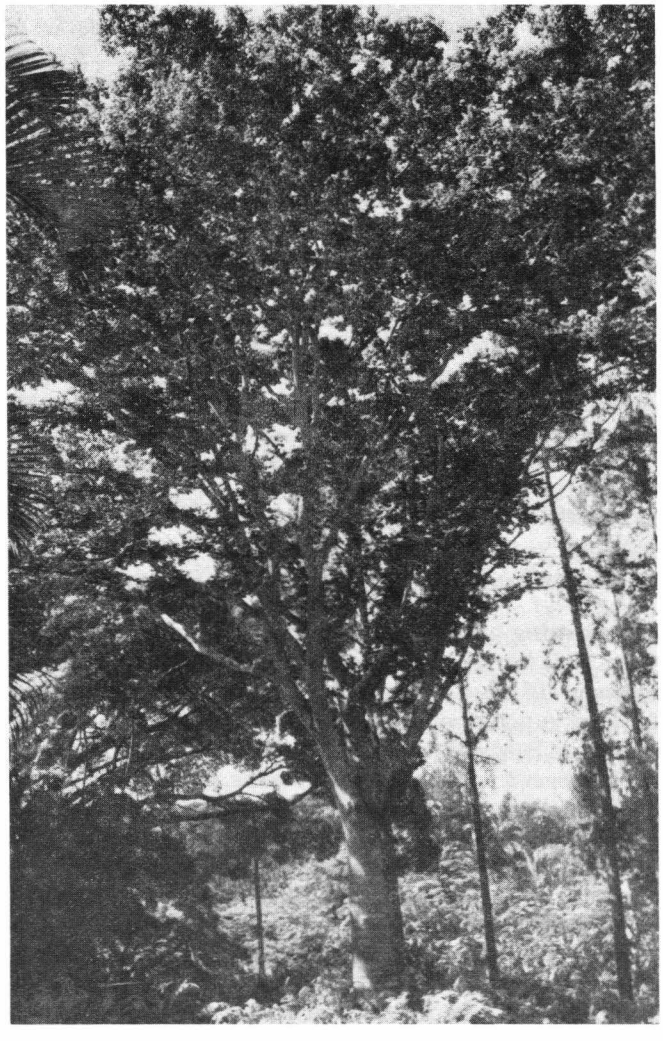

Figure 1.—*An algarrobo* (Hymenaea courbaril) *tree growing in Puerto Rico.*

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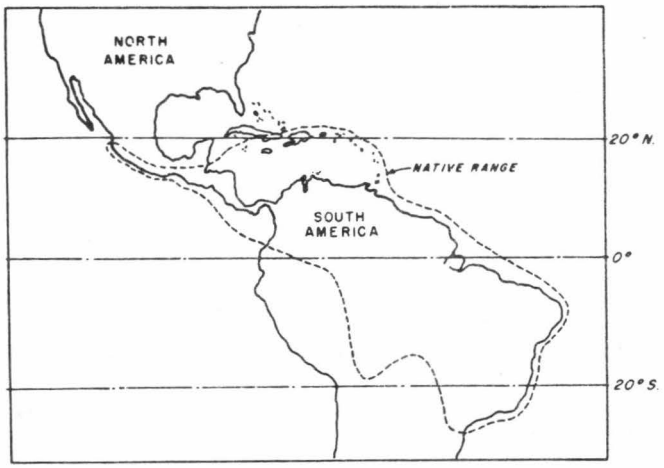

Figure 2.— *The native range of algarrobo* (Hymeneae courbaril) *in tropical America.*

semideciduous forest dominated by *Hura polyandra* Baill. and is associated with *Enterolobium cyclocarpum* (Jacq.) Griseb., *Luehea candida* (DC.) Mart., *Tabebuia rosea* (Bertol.) DC., *Licania arboria* Seeman, and *Apeiba tibourbou* Aubl. (*29*). Forest remnants in the moister parts of the dry "llanos" (plains) of Venezuela support an association of *H. courbaril* L., *Lonchocarpus velutinus* Benth., *Fagara chiloperone* (Mart.) Engl., *Allophylus occidentalis* (Swarts) Radlk, *Guazuma ulmifolia* Lam., *Casearia* spp., *Cordia bicolor* DC., and *Genipa americana* L. (*10*). Algarrobo dominates a secondary forest site in the subtropical moist forest in Puerto Rico. Important associates are: *Buchenavia capitata* (Vahl) Eichl., *Nectandra cariacea* (SW.) Griseb., *Manilkara bidentata* (A.DC.) Chev., and *Inga laurina* (SW.) Willd. (*35*). A site in the tropical wet forest of Costa Rica is also dominated by algarrobo, with the important associates *Trichilia* sp., *Persea americana* Mill., *Symphonia globulifera* L.f., *Carapa guianensis* Aubl., and *Protium* sp. (*30*). Algarrobo is occasionally found in nearly pure stands in Mexico (*27*).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—The white flowers are about 4-cm wide across the petals and are borne in terminal racemes (*16*) during spring and summer. Trees must be fairly large and receive full overhead light before they begin flowering. Seed pods mature about 9 months after flowering and fall over a period of about 3 months. Individual pods are 5 to 10 cm long, 2 to 3.5 cm wide, and 2.5 cm or more thick (*16*). The outer shell is thick, very hard, and will not open by itself. Inside this hard outer shell, a powdery, cream-colored pulp surrounds three or four large seeds.

Seed Production and Dissemination.—Seed collections from Brazil (*28*) and Puerto Rico (author, personal observation) yielded 475 and 253 ± 5 air-dry seeds per kilogram, respectively. A few to more than 100 pods may be produced by a single tree, but only part of the trees bear in any one year. Gravity is the only important means of dispersal in many of the Caribbean Islands. On the mainland of Central and South America, seeds are transported by agouties and probably peccaries, both of which open the pods and eat the pulp and sometimes the seeds (*13*). If the pods are left on the ground, the hard shell will eventually crack or rot enough to allow moisture to enter so the seeds can germinate. This may take several months because the pod shells are impregnated with a protective gum (*16*). If the pods are not opened, a majority of the seeds will rot within the pods (*23*). Seeds for planting are most easily obtained by collecting and shelling the freshly fallen pods. Seeds that are to be stored for more than 1 year should be refrigerated at 2 to 4 °C in a sealed container (*20*).

Seedling Development.—Germination of the seeds is epigeous (*23*). Seeds will germinate in 20 to 30 days with 40- to 90-percent success (*22, 28*). Scarification of seeds by nicking or soaking for 1 hour in concentrated sulfuric acid has increased germination percentage and reduced the germination time in Puerto Rican tests. After germination, stems elongate until seedlings are 15 to 20 cm tall and cotyledons leaves open and expand to full size (*23*). New seedlings, which are tender and fleshy, gradually lignify. Seedlings grown under 50-percent shade reached a 55-cm height about 78 days after germination (author, personal observation). Tests in Puerto Rico showed that full sun was better for nursery seedlings than shade. Containerized stock grown with full sunlight is ready to outplant in 60 days (*28*). Algarrobo seedlings grow at an angle with a drooping leader, a habit that may persist for 2 or 3 years (*23*). After reaching 2 to 2.5 m, the leader straightens up and a straight bole develops (*22*).

Algarrobo can be established using top-pruned, bare-root stock (*23*) or containerized seedlings (*28*). Direct seeding is feasible (*23*), but most of the seedlings in Puerto Rico failed for lack of sufficient weeding after emergence or because mice ate the succulent cotyledons (*22*). Underplanting was tried in Puerto Rico followed by partial cutting a year later to open the stand. After 18 months, the seedlings had grown only 25 cm, and only 23 percent survived. Many of the survivors, however, become dominant trees. Open planting sites and good weed control until the seedlings reach 2 m or so in height appear to be essential for best plantation establishment. The use of large planting stock (>1 m tall) may shorten the period of weed control and increase survival. Unfortunately, this has not been tested.

Vegetative Reproduction.—Algarrobo can be propagated vegetatively by using unlignified cuttings in misted beds with steam or electrically heated soil (*3*). The species coppices well and thus maintains itself in frequently cut-over areas (*22*); however, stumps of large trees do not coppice (*23*).

Sapling and Pole Stage to Maturity

Growth and Yield.—A moderate growth rate characterizes algarrobo. In Puerto Rico, it may take 2 years to reach 1 m in height. After that, growth rarely exceeds 1 m/yr. Three plantations in similar climates but differing soils in Puerto Rico[1] exhibited maximum heights of 3.6 m at 8

[1]Data on file at the Institute of Tropical Forestry, Southern Forest Experiment Station, Rio Piedras, Puerto Rico.

years, 11 m at 13 years, and 9 m at 20 years. Growth of algarrobo is steady, however. In the plantation that had a maximum height of 11 m at 13 years, when dominants and codominants were 44 years old they averaged 20 m in height and 38 cm in diameter at breast height (d.b.h.). The best trees in an 11-year-old plantation established by direct seeding on a poor site in Trinidad and Tobago measured 16 m in height and 16 cm in d.b.h. (*23*). The average was much lower. The mean diameter increment over a 2-year period for algarrobo trees, some of which were dominants in a natural stand in Puerto Rico, was 0.53 cm/yr (*35*). Algarrobo is a long-lived tree (*2*) and is capable of attaining large sizes. One tree measured in a survey in Costa Rica had a height of 50 m and a d.b.h. of 1.1 m (*30*). Rotation length necessary to grow trees to a 50-cm d.b.h. for sawlogs probably would be 45 to 65 years, depending on spacing and site quality.

Rooting Habit.—Seedlings of algarrobo develop a taproot with many fibrous laterals. As trees get older, a deep root system develops (*30*), and the roots often exude an abundance of resinous gum (*23*). Algarrobo trees usually grow without buttresses (*23*). Nodules (presumably formed by association with the nitrogen fixing bacteria, *Rhizobium* sp.) have been reported on the roots of algarrobo in Hawaii and the Philippines, but nodules were not found on the roots of algorrobo growing in Trinidad or Venezuela (*1*).

Reaction to Competition.—Algarrobo is intolerant of shade when mature. It will grow slowly under light shade and can persist under fairly heavy shade for a few years, but it needs full or nearly full overhead light to fully develop (*23*). Open-grown trees have short boles and wide crowns. Young trees growing under light shade apparently grow longer and straighter boles (*16*). This shade might best be managed as side shade from other closely spaced algarrobo trees or brushy species already on the site, as long as they are not allowed to overtop the crop trees. Seedlings and saplings of algarrobo are vulnerable to overtopping and smothering by weeds, brush, and fast-growing trees. Once they have established themselves as dominant trees, other trees in the stand probably have little effect on their growth.

Algarrobo made up 13 percent of the 10.3 m^2/ha of basal area in a natural stand in the subtropical moist forest of Puerto Rico (*35*). A 44-year-old plantation on a different site in the same life zone averaged 14.7 ± 1.2 m^2/ha (author, personal observation). No spacing or thinning guidelines are given in the literature. Tentatively, planting at 3- by 3-m spacing should be followed in 12 to 15 years by a heavy thinning once the trees have set their commercial bole length. Opening to fairly wide spacing is not a danger because epicormic branches do not form. When 24 algarrobo trees were measured, they had a mean crown-to-bole ratio (mean crown diameter/d.b.h.) of 22.8 ± 0.7 (author, personal observation). Projecting from this ratio, 77 trees per hectare could be carried to a final d.b.h. of 50 cm at harvest, assuming circular crowns just touching and full stocking.

Damaging Agents.—Algarrobo has no serious insect or disease problems. A weevil, (*Rhinochenus* sp.), which bores through the pod and eats the seeds, was noted in Costa Rica (*12*) and is probably also found in Trinidad and Tobago (*23*). Three insects, *Acanthoscelides* sp., *Hypothenemus buscki* (Hopkins), and *Myelois decolor* Zeller, were found feeding inside algarrobo pods in Puerto Rico (*24*). An unidentified insect in Trinidad and Tobago cuts twigs and small branches from the tree after depositing eggs in them (*23*). Leaf-cutter ants (*Atta* spp.) harvest newly formed (but not mature) leaves (*13*). Algarrobo wood is highly resistant to attack by the West Indian dry-wood termite, *Cryptotermes brevis* (Walker) (*36*), but deadwood in the forest is eaten by the wet-wood termites *Nasutitermes costalis* (Homgren) and *N. nigricepts* (Haldeman) (*24*). Tested as pilings, algarrobo had little resistance to marine borers in Hawaii (*7*) and North Carolina (*6*). Compared with 39 other species of tropical hardwoods in Venezuela, algarrobo ranked among the most durable in each case when challenged with 4 species of wood-rotting fungi (*31*). Tests of untreated stakes indicated that this wood is durable in the ground (*19*). However, the heartwood of the majority of trees from Guayana was not durable when inoculated and incubated with a white-rot fungus and only moderately durable when incubated with a brown-rot fungus (*6*). The species is listed as being susceptible to breakage during hurricanes (*34*).

SPECIAL USES

Algarrobo is primarily a timber tree, but it has many other uses as well. The heartwood seasons to a russet or reddish-brown color with darker streaks; the sapwood is white, gray, or pinkish in color (*5, 6*) and tends to be relatively thick. The wood is sometimes difficult to season and suffers slight to considerable loss due to check and warp (*5, 18*). There is a 4.5-percent radial and an 8.5-percent tangential shrinkage of the wood while drying (*5*). Algarrobo wood is very heavy; specific gravity averaged 0.70 g/cm^3 in Guayana (*5*), 0.89 g/cm^3 in Guadeloupe (*25*), 0.77 g/cm^3 in Brazil (*26*), and 0.84 g/cm^3 in Puerto Rico (*18*). The wood is strong, hard, and tough. Bending strength, modules of elasticity, and crushing strength are listed as 2,140 kg/cm^2, 162,000 kg/cm^2, and 880 kg/cm^2, respectively (*25*). Algarrobo is moderately difficult to saw and machine and difficult to plane (*5*). It glues well, will bend well after steaming, finishes fairly well, and will hold screws without splitting (*18*). The wood is well suited for the manufacture of tool handles and some sporting equipment, steam-bent furniture and boat parts, flooring, and stair treads. Other uses include furniture, turnery and craft items, interior trim, beams, and railroad ties (*5, 18, 37*). The species is recommended for decorative veneer (*32*), and the wood can also be used as a source of hardwood pulp (*26*) and for firewood and charcoal.

Algarrobo finds some use as an ornamental and shade tree in yards, parks, and streets. Drawbacks for these uses are that the heavy, hard pods have broken car windshields as they fall, and if the fallen pods break, they emit an unpleasant odor (*16*). The species is used occasionally for coffee shade (*4*). The powdery pulp surrounding the seeds is edible and often eaten by children, although it has an odor that may be considered offensive (*4, 17, 23*). The pulp—plain, toasted, or fermented—is used to make a drink (*4, 11, 16*). The powdery pulp contains 3.2-percent sugar, 1.1-percent fat, and 35.8-percent crude fiber (*11*). The pods are not eaten

by cattle or goats, but if the seeds and pulp are removed and ground, they are readily consumed by livestock (*33*). The leaves are not eaten. A gum or resin called South American copal, exuded by the trunk and the roots, is used in the manufacture of varnish and incense (*17*). A bark infusion is used in folk medicine as a laxative, and the fruit pulp is used as an antidiarrheal agent (*16*).

GENETICS

The genus *Hymenaea* contains 17 species; 16 are neotropical and 1 African (*15*). *Hymenaea courbaril* has been divided into five varieties: *H. courbaril* var. *courbaril* occupies most of the range and four varieties of H. courbaril (var. *altíssima*, var. *longifolia*, var. *stilbocarpa*, and var. *villosa*) are all confined to central and south central Brazil (*15*). Nearly all trees flower every year and contribute to the pollen pool, but later many of the trees abort their developing pods for unknown reasons. Algarrobos are probably self-incompatible (*13*).

LITERATURE CITED

1. Allen, O. N.; Allen, Ethel K. 1981. The Leguminoseae, a source book of characteristics, uses, and nodulation. Madison, WI: University of Wisconsin Press. 812 p.
2. Aristeguieta, Leandro. 1962. Arboles ornamentales de Caracas. Caracas, Venezuela: Universidad Central de Venezuela, Consejo de Desarrollo Científico y Humanístico. 218 p.
3. Baily, L.H. 1941. The standard cyclopedia of horticulture. New York: MàcMillan. 3,639 p.
4. Chavelas-Polito, Javier; Gonzalez-Vicente, Carlos E. 1985. Catalogo de arboles forestales del sureste de México que producen frutos comestibles. Catalogo 10. Mexico City, Mexico: Secretaria de Agricultura y Recursos Hidraulicos. 22 p.
5. Chudnoff, Martin, 1984. Tropical timbers of the world. Agric. Handb. 607. Washington, DC: U.S. Department of Agriculture. 466 p.
6. Dickinson, Fred E.; Hess, Robert W.; Wangaard, Frederick F. 1949. Properties and uses of tropical woods, I. Tropical Woods. 95: 1–145.
7. Edmondson, Charles H. 1949. Reaction of woods from South America and Caribbean areas to marine borers in Hawaiian waters. The Caribbean Forester. 10(1): 37–42.
8. Hoffman, José A.J. 1975. Climatic atlas of South America. Budapest, Hungary: UNESCO Cartographia. [Not paged].
9. Holdrige, L.R. 1967. Life zone ecology. San José, Costa Rica: Tropical Science Center. 206 p.
10. Hueck, Kurt. 1961. The Forests of Venezuela. Forst Forschungen 14/6. Hamburg, Germany: Verlag Paul Parey. 106 p.
11. INIREB. 1977. El cuapinol. Comunicado 20. Xalapa, Veracruz, Mexico: Instituto de Investigaciones Sobre Recursos Botanicos. 3 p.
12. Janzen, Daniel L. 1975. Behavior of *Hymenaea courbaril* when its predispersal seed predator is absent. Science. 189(4194): 145–147.
13. Jansen, Daniel L. 1983. Costa Rican Natural History, Chicago, IL: University of Chicago Press. 816 p.
14. Joly, C.A.; Crawford, R. M. M. 1982. Variation in tolerance and metabolic responses to flooding in some tropical trees. Journal of Experimental Botany. 33(135): 799–809.
15. Lee Y. T.; Langenhein, J.H. 1974. Additional new taxa and new combinations in *Hymenaea* (Leguminosae, Caesalpinioideae). Journal of the Arnold Arboretum. 55(3): 441–452.
16. Liogier, Alain H. 1978. Arboles Dominicanos. Santo Domingo, Dominican Republic: Academia de Ciencias de la Republica Dominicana. 220 p.
17. Little, Elbert L., Jr.; Wadsworth, Frank H. 1964. Common trees of Puerto Rico and the Virgin Islands. Agric. Handb. 249. Washington, DC: U.S. Department of Agriculture. 548 p.
18. Longwood, Franklin R. 1961. Puerto Rican woods. Agric. Handb. 205. Washington, DC: U.S. Department of Agriculture. 167 p.
19. Longwood, Franklin R. 1962. Present and potential commercial timbers of the Caribbean. Agric. Handb. 207. Washington, DC: U.S. Department of Agriculture. 167 p.
20. Marrero, José. 1943. A seed storage study of some tropical hardwoods. Caribbean Forester. 4(3): 99–106.
21. Marrero, José. 1947. A survey of the forest plantations in the Carribean National Forest, M.S. Thesis. Ann Arbor, MI: University of Michigan. 167 p.
22. Marrero, José. 1949. Tree seed data from Puerto Rico. Caribbean Forester. 10(1): 11–36.
23. Marshall, R.C. 1939. Silviculture of the trees of Trinidad and Tobago, British West Indies. London, England: Oxford University Press. 247 p.
24. Martorrell, Luis F. 1975. Annotated food plant catalog of the insects of Puerto Rico. Río Piedras, PR: Agricultural Experiment Station, University of Puerto Rico, Department of Entomology. 303 p.
25. Parant, B.; Chichignoud, M.; Curie, P. [n.d.] Les bois de Guadeloupe. Pointe-a-Pitre, Guadeloupe: Centre Technique Forestier Tropical. 20 p.
26. de Paula, José E. 1977. Anatomia de madeiras la Amazonia com vistas a polpa e pael. Acta Amazonica. 7(2): 273–288.
27. Pennington, T.D.; Sarukhan, José. 1968. Arboles tropicales de Méjico. Mexico City, Mexico: Instituto Nacional de Investigaciones Forestales, Secretaría de Agricultura y Ganadería de Mexico. 413 p.
28. Pereira, Antonio P. 1982. Ensaios em viveiro florestal e fruitificacao de algumas especies Amazonicas. Silvicultura em Sao Paulo. 16A(2): 1135–1138.
29. Rzedowski, J. 1981. Vegetacion de Mexico. Mexico City, Mexico: Editorial Limusa. 432 p.
30. Sawyer, John O.; Lindsey, Alton A. 1971. Vegetation of the life zones in Costa Rica. Indianapolis, IN: Indiana Academy of Science. 214 p.
31. Silverborg, Savel B.; de Mayorca, Lerida; Conjos, Jesus. 1970. Durabilidad relativa de algunas maderas venezolanas. Revista Forestal Venezolana. 13(19&20): 61–72.
32. van der Slooten, H.J. 1970. Evaluation of eighteen wood species from Guayana for veneer and plywood manufac-

ture. Forest Industries Development Survey, Tech. Rep. 13. Rome, Italy: Food and Agriculture Organization of the United Nations. 93 p.
33. Susano-Hernandez, Roberto. 1981. Especies arboreas forestales susceptibles de aprovecharse como forraje. Ciencia Forestal. 6(29): 31–39.
34. Wadsworth, Frank H.; Englerth, George H. 1959. Effects of the 1956 hurricane on forests in Puerto Rico. Caribbean Forester. 20(3/4): 38–51.
35. Weaver, Peter L. 1987. Tree growth in several tropical forests of Puerto Rico. Res. Pap. SO-152. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15 p.
36. Wolcott, George N. 1946. A list of woods arranged according to their resistance to the attack of the West Indian dry-wood termite *Cryptotermes brevis* (Walker). The Caribbean Forester. 7(4): 329–334.
37. Zavala-Zavala, David. 1978. Utilizacion de especies tropicales en la produccion de durmientes para el metro. Ciencia Forestal. 3(15): 3–10.